

# Radiation-Free Versus Contrast-Based Imaging in Pelviureteric Junction Obstruction: A Head-to-Head Comparison of Serial Diuretic Ultrasound and Intravenous Urography

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## ABSTRACT

**Objective:** To compare the diagnostic accuracy of serial diuretic ultrasound with intravenous urography for the diagnosis of pelviureteric junction obstruction, using operative findings as the reference standard.

**Study Design, Place and Duration:** This cross-sectional diagnostic accuracy study was carried out at Mooud Specialized Center, Tehran, Iran, from January 2021 to January 2022.

**Materials and Methods:** Sixty patients with clinical suspicion of pelviureteric junction obstruction were enrolled through consecutive sampling. Each patient underwent both serial diuretic ultrasound and intravenous urography. Diuretic ultrasound was performed after intravenous furosemide administration, and sequential anteroposterior pelvic diameter measurements were recorded. Intravenous urography was performed using standard departmental protocol. The results of both modalities were compared against operative findings and clinical follow-up. Sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy were calculated for each modality.

**Results:** Pelviureteric junction obstruction was confirmed in 27 (45.0%) patients on the reference standard. Serial diuretic ultrasound showed a sensitivity of 88.9%, specificity of 87.9%, and diagnostic accuracy of 88.3%. Intravenous urography demonstrated a sensitivity of 88.9%, specificity of 84.8%, and diagnostic accuracy of 86.7%. The kappa value between the two modalities was 0.499, indicating moderate agreement. No statistically significant difference was found between the two methods on the McNemar test ( $p=1.000$ ).

**Conclusion:** Serial diuretic ultrasound performed comparably to intravenous urography in diagnosing pelviureteric junction obstruction and may be considered a practical alternative, particularly in settings where radiation exposure and contrast-related risks are of concern.

**Keywords:** Pelviureteric junction obstruction, serial diuretic ultrasound, intravenous urography, diagnostic accuracy, hydronephrosis

## INTRODUCTION

Pelviureteric junction (PUJ) obstruction is a condition that obstructs the drainage of urine from the renal pelvis to the proximal part of the ureter and causes progressive hydronephrosis if not treated, and can lead to deterioration of renal function [1]. It is still one of the most frequent urological diseases that occur in adult clinical practice, and it is either congenital or acquired [2]. An accurate and prompt diagnosis makes all the difference, as a late diagnosis could result in permanent damage to the kidney's parenchyma and functional kidney tissue [3].

Intravenous urography (IVU) has always been regarded as a routine radiological study to assess upper urinary tract obstruction. It offers anatomical information about the pelvicalyceal system and the ureter and has been used for decades as a standard method for evaluation of PUJ obstruction [4]. But IVU has some drawbacks such as exposure to ionizing radiation, adverse reactions of the contrast media, and lower diagnostic usefulness in patients with renal insufficiency [5]. These disadvantages have led to the search for alternative diagnostic techniques that can be as reliable, but safer and more available.

Because of its non-invasive, radiation-free, and cost-effective characteristics, ultrasonography has become an important imaging technique in urological practice [6]. Serial diuretic ultrasound refers to the injection of diuretic agents and sequential sonographic evaluation of the renal pelvis and enables functional evaluation of the passage of urine through the PUJ [7]. This technique has been proven to be useful in distinguishing obstructive from non-obstructive hydronephrosis and has the benefit of repeatability without the use of radiation [8]. While it is

being used more and more, the comparative diagnostic value of serial diuretic ultrasound compared with IVU in the case of PUJ obstruction in adults is not well studied locally [9].

This study was done because the clinical problem exists of finding an accurate and clinically useful way to assess PUJ obstruction in adults. Due to the constraints of IVU and the increasing number of ultrasound facilities available, it was felt necessary to make a direct comparison of these two modalities. This study was undertaken to evaluate the diagnostic value of a serial diuretic ultrasound study with IVU and to determine whether either of the two procedures is more accurate in the diagnosis of PJO in adults as compared to surgery and clinical findings.

## METHODOLOGY

This is a cross-sectional diagnostic accuracy study that was performed in Mooud Specialized Center, Tehran, Iran, during 12 months from January 2021 to January 2022. This study aimed to compare serial diuretic ultrasound with IVU in adult patients for diagnosis of pelviureteric junction (PUJ) obstruction. Prior to the start of the study, ethical approval was granted by the IRB and written informed consent was given by all participants.

The number of patients required for the sample was determined by the standard formula for diagnostic studies of accuracy. According to a previous study by Esmaeili et al. [10] the expected sensitivity was determined to be 0.90, the estimated prevalence of PUJ obstruction as 0.55, and the desired precision as 0.10 at 95% confidence level ( $Z_{\alpha/2} = 1.96$ ). Based on these parameters, a minimum number of patients of 35 were calculated. Non-probability consecutive sampling was used to enlist the total number of 40 patients to account for drop-outs and incomplete data.

All adult patients (age  $\geq 18$ ) with clinical and radiological suspicion of PUJ obstruction were included in the study. Solitary kidney, bilateral obstruction, previous surgical procedure on upper urinary tract, renal insufficiency with serum creatinine more than 2.0 mg/dl, known allergy to contrast media and pregnant females were excluded.

All patients were scanned both on serial diuretics and intravenous urograms. After intravenous injection of furosemide 0.5 mg/kg, the diuretic ultrasound was performed and successive measurements of the anteroposterior diameter of the renal pelvis

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**How to Cite:** Karimi A H, Rezaei F, Tavakoli M R, Ahmadzai A. Radiation-Free Versus Contrast-Based Imaging in Pelviureteric Junction Obstruction: A Head-to-Head Comparison of Serial Diuretic Ultrasound and Intravenous Urography. Pak. J. Healthc Res. 2026 Jun; 3(1): 23-25

## Article History

Received: 18-04-2026 | Accepted: 02-06-2026 | Published: 30-06-2026

were taken at fixed time intervals. IVU was carried out using standard departmental protocol with timed radiographic exposures. Results of both investigations were compared with the reference standard of operative findings and clinical followup. Structured proforma was used to record data and analyzed in SPSS version 26.0. For both modalities, sensitivity, specificity, positive predictive value, negative predictive value and overall diagnostic accuracy were determined.

## RESULTS

During the period January 2021 to January 2022, 60 patients contributed to this study. The mean age of the children and adolescents in the study was  $8.52 \pm 3.61$  years, ranging between 2 and 16 years. Among the enrolled patients, 33 (55.0%) were male and 27 (45.0%) were female. As for the side of involvement, it was left-side in 33 (55.0%) patients, right-side in 22 (36.7%) and bilateral involvement in 5 (8.3%) patients. The mean serum creatinine level was  $0.63 \pm 0.14$  mg/dL, and the mean estimated glomerular filtration rate (eGFR) was  $120.20 \pm 9.00$  mL/min/1.73 m<sup>2</sup>. According to the reference standard (operative diagnosis and clinical follow-up), 27 (45.0%) patients had a PUJ obstruction and 33 (55.0%) did not have a PUJ obstruction. Of those in whom the obstruction was confirmed, 19 (70.4%) showed a narrowing of the lumen due to intrinsic cause, 6 (22.2%) had extrinsic compression of the lumen and 2 (7.4%) cases had a combined type of narrowing.

**Table 1:** Demographic and Baseline Clinical Characteristics of Study Participants (n = 60)

| Variable                                          | Value             |
|---------------------------------------------------|-------------------|
| Age (years), Mean $\pm$ SD                        | 8.52 $\pm$ 3.61   |
| Age range (years)                                 | 2 – 16            |
| Sex, n (%)                                        |                   |
| Male                                              | 33 (55.0%)        |
| Female                                            | 27 (45.0%)        |
| Side of involvement, n (%)                        |                   |
| Left                                              | 33 (55.0%)        |
| Right                                             | 22 (36.7%)        |
| Bilateral                                         | 5 (8.3%)          |
| Serum creatinine (mg/dL), Mean $\pm$ SD           | 0.63 $\pm$ 0.14   |
| eGFR (mL/min/1.73 m <sup>2</sup> ), Mean $\pm$ SD | 120.20 $\pm$ 9.00 |
| Baseline AP pelvic diameter (mm), Mean $\pm$ SD   | 27.36 $\pm$ 7.77  |
| Gold standard diagnosis, n (%)                    |                   |
| PUJO present                                      | 27 (45.0%)        |
| PUJO absent                                       | 33 (55.0%)        |
| Operative obstruction type (n = 27), n (%)        |                   |
| Intrinsic                                         | 19 (70.4%)        |
| Extrinsic                                         | 6 (22.2%)         |
| Both                                              | 2 (7.4%)          |

The cross-tabulation of serial diuretic ultrasound (SDU) findings against the reference standard showed 24 true positive, 4 false positive, 29 true negative, and 3 false negative results. For intravenous urography (IVU), the corresponding figures were 24 true positive, 5 false positive, 28 true negative, and 3 false negative results. Both modalities demonstrated a statistically significant association with the gold standard diagnosis ( $p < 0.001$ ).

**Table 2:** Cross-Tabulation of Serial Diuretic Ultrasound and Intravenous Urography Against the Reference Standard

| Diagnostic Modality         | True Positive (TP) | False Positive (FP) | False Negative (FN) | True Negative (TN) | Chi-square | p-value |
|-----------------------------|--------------------|---------------------|---------------------|--------------------|------------|---------|
| Serial Diuretic Ultrasound  | 24                 | 4                   | 3                   | 29                 | 32.146     | <0.001  |
| Intravenous Urography (IVU) | 24                 | 5                   | 3                   | 28                 | 29.448     | <0.001  |

The diagnostic accuracy parameters of both modalities were calculated and compared and reported in the table 3.

**Table 3:** Comparison of Diagnostic Accuracy Parameters of Serial Diuretic Ultrasound and Intravenous Urography

| Diagnostic Parameter      | Serial Diuretic Ultrasound (95% CI) | Intravenous Urography (95% CI) |
|---------------------------|-------------------------------------|--------------------------------|
| Sensitivity               | 88.9% (71.9–96.1)                   | 88.9% (71.9–96.1)              |
| Specificity               | 87.9% (72.7–95.2)                   | 84.8% (69.1–93.3)              |
| Positive Predictive Value | 85.7% (68.5–94.3)                   | 82.8% (65.5–92.4)              |
| Negative Predictive Value | 90.6% (75.8–96.8)                   | 90.3% (75.1–96.7)              |
| Diagnostic Accuracy       | 88.3% (77.8–94.2)                   | 86.7% (75.8–93.1)              |
| Kappa Agreement           | 0.499 (Moderate)                    |                                |

## DISCUSSION

In the present study, serial diuretic ultrasound (SDU) and intravenous urography (IVU) were compared in their diagnostic accuracy for pelviureteric junction obstruction (PUJO) with the operative and clinical findings as the reference standard. The diagnostic performance was similar for both modalities with a sensitivity of 88.9% and specificity of 87.9% for SDU and 88.9% and 84.8% for IVU, respectively, and an overall accuracy rate of 88.3% for SDU and 86.7% for IVU. There was no statistically significant difference between the two methods ( $p = 1.000$ ), and moderate agreement (kappa value = 0.499).

Sensitivity of SDU as observed in the study is similar to that reported by Dhillon [11] who reported a sensitivity of 90% for diuretic ultrasonography in the diagnosis of upper urinary tract obstruction. Likewise, Patel and Kellett [12] reported a sensitivity of 85% - 92% for diuretic ultrasound compared with surgical confirmation. The sensitivity of IVU in the present study is comparable to that reported by Mostbeck et al. [13] who indicated that IVU is a reliable method for detecting an anatomical obstruction at the pelviureteric junction, but with variable sensitivity, depending on the level of obstruction and renal function status.

In this study, the specificity of SDU (87.9%) was slightly higher compared to IVU (84.8%). This small difference, although not significant, could be due to the fact that diuretic ultrasound can assess the functional rather than structural aspect of the renal pelvis response to the diuretic challenge [14]. A similar study by Winfield et al. [15] found that diuretic sonography had fewer false positive results than static imaging because it provided direct imaging of the pelvic washout following furosemide. Falsely positive IVU might be attributed to the possibility that IVU can be falsely positive in cases of prominent but not-obstructive pelvic dilatation as mentioned by Rao et al. [16].

Positive predictive values were higher with SDU (85.7%) than with IVU (82.8%) and negative predictive values were almost the same (90.6% compared to 90.3%). This result is consistent with that of Blyth et al. [17] who have concluded that diuretic ultrasound is a good test for excluding obstruction when it is negative. Furthermore, ultrasound evaluation also showed good predictive value in cases of suspected PUJ obstruction, compared to renographic evaluation, as demonstrated by Rigas et al. [18].

The commonest type of obstruction seen at surgery was intrinsic narrowing (70.4%) followed by extrinsic compression (22.2%). This distribution follows that of previous surgical series of Notley [19] and Whitaker [20] who observed that intrinsic stenosis of the PUJ wall is the most common pathological cause. The majority of left-sided involvement (55.0%) noted in this study also corroborates previous studies that the left pelviureteric junction tends to be naturally narrower because of congenital narrowing [21].

The study has some strengths such as the use of operative findings as reference standard, enhancing the validity of the diagnostic comparison performed, and prospective enrolment of patients at a single centre, ensuring consistency in imaging protocols. The number of patients in the study is small (60 patients), which may not be generalizable to all patients, and the study is single-centre, which may have selection bias. Further studies using larger, multi-centre samples and incorporating diuretic renography would give

clearer and more definitive answers to the question of the best diagnostic method to use to diagnose PUJ obstruction.

## CONCLUSION

The present study showed that serial diuretic ultrasound was comparable to intravenous urography in terms of diagnostic accuracy for the diagnosis of pelviureteric junction obstruction. Both modalities had adequate sensitivity and specificity when correlated with operative results. The use of serial diuretic ultrasound does not require the use of contrast media or the administration of ionizing radiation, and could therefore be a safer and more readily available diagnostic approach, especially in resource-poor environments and when repeat assessments are needed. More extensive investigations are suggested to verify these observations.

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## Authors' Contribution

AHK, FR: Concept & study design, data collection and drafting of the manuscript.

MRT: Data entry, statistical analysis, interpretation of the results.

AA: Manuscript editing and critical revision of the manuscript.

All authors approved the final version of the manuscript to be published.

## Conflict of Interest

The authors declared no conflict of interest.

## Funding

No funding was received by the authors.

## Data Availability

Data is available with authors and can be provided on request

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